at scattered places, the Mercator projection may be recommended for these synoptic charts, with the possible addition of supplementary maps in polar projection for special occasions. In any case there will surely be no one to prefer the wholly unsuitable projection adopted, for example, for the Chart of Annual Rainfall in Berghaus' Physikalisches Atlas, 1887 edition, wherein the greatest distortion occurs in the Temperate Zones, the very region of which we know the most.

From the theoretical viewpoint the one daily simultaneous observation may be made at any hour; practically Greenwich noon would probably be the best time, since then the late afternoon and the early morning hours, which are the most difficult to secure in simultaneous observations, almost without exception will fall to the lot of the Pacific stations where these hours offer no considerable difficulties to observers on shipboard. It is evident that such extensive synoptic charts will further a more comprehensive knowledge of the dynamic phenomena of our atmosphere, and be of great practical advantage in the forecasting of weather and storms; thus it would not be necessary to make special provision for this latter work.

I doubt not that this view will find warm supporters among the members of this congress, but if it is to emerge from the realm of simple desire where so many unanimous resolves of former meteorological congresses still abide, then this Chicago congress must also consider the means for executing such a resolution. Perhaps, indeed, such arrangements have already been perfected very much as when at Vienna Brig. Gen. Albert J. Myer initiated the system of simultaneous observations over the Northern Hemisphere, undertaken and published by the United States Signal Service, whose chief he then was. [See the following extracts from the official protocol of the Vienna congress.—C. A.]

If the United States of North America, in its former generous manner, shall guarantee the means for collecting, discussing, and publishing these proposed new simultaneous observations for the whole globe, it may be safely assumed that no nation will withhold its cooperation in organizing the simultaneous observations in its own territory for this mutually beneficial work. But since it is scarcely to be expected that a single nation will again make so great a sacrifice for the international welfare, the proposed undertaking can only be realized by assigning its execution to an international meteorological bureau founded and maintained at the expense of all nations. The establishment of such an international bureau, but for other purposes, was discussed at the International Meteorological Conference at Munich in 1891, and referred to the International Meteorological Committee for further consideration. The congress at Chicago might therefore request the latter committee to consider the present question as an additional task for such an international meteorological bureau.

[Extracts from Bericht über die Verhandlungen des Internationalen Meteorologen-Congresses zu Wien, 2.-16. September, 1873. Protokolle und Beilagen. Wien. 1873. vi., 114 p. 4°.]

PROTOCOL OF THE SEVENTH SESSION, SEPTEMBER 12, 1873, 10:20 A. M.

Chairman: Mr. SCOTT.

After the minutes of the sixth plenary session were read and approved, the chairman read the written proposition, published as First Appendix to Protocol No. 7, from Delegate General Myer, concerning the institution of at least one daily simultaneous observation, and announced that the discussion of this proposal had been assigned to the next session. (Pp. 23–24.)

1. BEILAGE ZUM PROTOKOLL DER VIIten SITZUNG. LETTER OF GENERAL ALBERT J. MYER TO THE CONGRESS.

METEOROLOGICAL CONGRESS,
Vienna, September 11, 1873.

To the Congress.

GENTLEMEN: I have the honor to submit the following proposition: [1]
"That it is desirable that with a view to their exchange at least one uniform observation of such character as to be suitable for the preparation of synoptic charts be taken and recorded daily and simultaneously at as many stations as practicable throughout the world."

I am, gentlemen, very respectfully,
(Signed) ALBERT J. MYER,
Brigadier General, Chief Signal Officer, U. S. A.

PROTOCOL OF THE EIGHTH SESSION, SEPTEMBER 13, AT 10.35 A. M.

* * * Next came the discussion of the proposal made by Gen. A. Myer (introduction of simultaneous observations over the whole Northern Hemisphere, appendix 1 to protocol of the seventh session).

First, Mr. Myer stated that he was commissioned by the War Department of the United States of North America to assure the congress of the deep interest taken by the department in all that concerns advance in the system of storm warnings and its desire that the exchange of international telegraphic weather reports shall find the greatest possible distribution. Turning then to his proposal, Mr. Myer stated that it seemed superfluous to argue for the actual establishment of it since the importance of simultaneous observations would undoubtedly be at once conceded by all.

The proposal was supported on several sides. Mr. Hoffmeyer announced that he could support it only in case no very great practical difficulties were present, because it could not be held that the scientific results would justify any very great sacrifice for their sake.

Mr. Buys-Ballot drew attention to his own "Suggestions," wherein he had pointed out simultaneous meteorological observations as a desirable object.

After Mr. Myer had again emphasized the fact that his proposal only called for a declaration by the congress that simultaneous observations over the whole earth were a desirable consummation, the resolution was unanimously adopted. * * * (P. 27.)

A CLASSIFICATION OF THE METHODS OF TRANSITION FROM RAIN TO BLUE SKY.

By Prof. WILLIS I. MILHAM.

[Dated Williams College, Williamstown, Mass., Feb. 20, 1914.]

INTRODUCTION.

The occurrence of rain or snow and also of most of the thundershowers of summer is due, as is well known, in nearly every instance to the passage of an extratropical cyclone or area of low barometric pressure near the place in question. Rain or snow now and then result from a V-shaped depression, or from an overgrown cumulus cloud, or from the action of a barrier, or from the condensation of moisture from a purely local source, and summer thundershowers are also sometimes due to purely local conditions, but these cases are too few in comparison with the whole number to merit further consideration. In winter, a passing low is generally attended by a continuous fall of rain or snow for some hours. In summer, warm, sultry weather with thundershowers, particularly in its southern quadrants, is the usual accompaniment of a passing low.

The distribution of the meteorological elements (temperature, pressure, wind, moisture, cloud, precipitation) about an area of low pressure has been much studied by many observers, and the statistical method has been the usual way of studying these formations. Most of the books on meteorology contain in more or less detail the generalizations from these statistics, which may be

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[1] Adopted at the VIIIth Session, Sept. 13, 1873 (p. 58.)

expressed as laws, in tables, or by means of diagrams (1). The distribution of the meteorological elements about a low is not exactly the same for all countries or for all parts of the same country and there is also a difference depending upon the seasons. Thus the geographical and seasonal changes ought to be studied as well as the distribution itself. But the differences are not large as a low is very much the same formation the world around.

The sequence of cloud forms before, during the intervals between, and after rains has also been much studied. The work of the Blue Hill Observatory near Boston is particularly worthy of mention, and an article by Clayton in the Annals of the Harvard College Observatory, Volume XXX, treats this question in detail. This, to be sure, is only one phase of the general question of the distribution of the meteorological elements about a low, but the change in cloud forms and their direction of motion, the occurrence of rain or snow, and the direction of the wind are the factors which can be observed without instruments and are the most conspicuous and interesting in the sequence of events which accompany the passing of a low.

It is the distribution of the elements about a *normal* or *typical* low and the *normal* or *usual* sequence of cloud forms which is determined by these statistical investigations. If every low were normal, the sequence of events in passing from rain to blue sky would always be the same. Any observer of weather changes knows that this is not the case, and the reason is that lows almost never conform exactly to the normal or type form. The question treated in this paper is whether the methods of transition from rain to blue sky can be classified in different ways, so that by stating in which group a low belongs, its characteristics are at once apparent to anyone familiar with the various types.

I. GRADUAL SHIFT VERSUS RAPID SHIFT.

The first great difference between lows is whether, as one passes through the southern quadrants, there is a gradual veering of the wind from some easterly quarter into the northwest, or whether the change is almost instantaneous. In the first case the sequence of events is usually as follows: At first the wind begins to blow gently from the east, the pressure decreases slightly, cirrus clouds make their appearance, and the temperature and moisture begin to increase. Next, the barometer drops a little more, the wind direction changes to the southeast and the velocity becomes a little greater, the cirrus clouds thicken to cirro-stratus or cirro-cumulus, and the temperature and moisture continue to rise. In the wintertime, as the popular phrase goes, the weather has begun to moderate. In the summertime it is the beginning of a period of sultriness. The pressure now drops still more, the wind veers a little and blows harder, the cirriform clouds go through their regular transition into nimbus, and the temperature and moisture are high and increasing. Now comes a period of rain or snow, with barometer still dropping and finally reaching its lowest. The wind, meantime, has slackened somewhat and veered a little, and is perhaps now blowing from the south or southwest. The temperature and moisture still continue high. The wind now veers rather quickly into the southwest, then west, and finally northwest. The barometer begins to rise, the precipitation grows less, and the temperature and moisture decrease. Soon the nimbus clouds break up into fracto-nimbus, perhaps disclosing an upper cloud area. The fracto-nimbus then changes into strato-cumulus, and finally cumulus or fracto-cumulus, with a clear sky at night. In the meantime the wind blows from the northwest with increasing velocity, the barometer is rising, and the temperature drops rapidly. The air also becomes much drier. In the summer the dry, cool, northwest wind has replaced the oppressive sultriness of a few days before. In the winter the thaw or warm spell has been replaced by a cold snap.

If, on the other hand, the windshift is very sudden, the low possesses what may be called a wind-shift line, and the sequence of events is then somewhat different. The coming of the rain or snow is just as before, but the wind ceases to veer and remains from the south or some southerly quarter. The rain or snow usually ceases for a time, and the lower nimbus cloud layer usually breaks in places or entirely disappears, leaving an upper layer of cirriform or alto clouds. The temperature and moisture remain high. Soon the black bank of cloud begins to appear all along the western horizon and then mounts higher and higher. In a moment the wind snaps into the northwest and blows with considerable velocity. A squall of snow or a heavy fall of rain, perhaps with thunder and lightning, commences, and the temperature drops as if by magic. Soon the precipitation ceases, the lower cloud layer breaks up, and the sequence of events is as before.

In the United States about one low in seven is accompanied by this sharp wind shift. In Europe it is said to be much more common. Its cause is probably the way in which the weather control is transferred from the passing low to the coming high. A coming high has on its front masses of cold air from the northwest. These either overrun or underrun the warm, moisture-laden air of the low and thus cause a rolling of the air about a long, horizontal axis, and to this is due the sudden wind shift. If the replacement of the warm, moist air by the colder air from the northwest is a more gradual process, a low of the first kind is the result.

The two accompanying diagrams (Figs. 1 and 2) show the distribution of the meteorological elements about these two kinds of lows. The solid lines are isobars, or lines of equal pressure; the dashed lines are isotherms, or lines of equal temperature. The wind direction and velocity are indicated by the direction and length of the arrows. The cloud forms on the east are first cirrus, then the transition clouds, and finally nimbus, which breaks up on the west usually into strato-cumulus. By moving these diagrams slowly from left to right, so that a place passes through their southern quadrants, the sequence of meteorological events due to the passage of such lows becomes at once evident.

II. THE THREE TYPES OF GRADUAL WIND SHIFT.

In the first of the preceding cases, when the wind veers gradually and continuously from some easterly direction until it finally reaches the northwest, it is of importance to note the direction of the cloud motion as compared with that of the surface wind. While it is raining both clouds and wind usually come from the same easterly or perhaps southerly quarter. When the wind finally reaches the northwest and blue sky has appeared, the clouds generally come from the northwest as well. During the shifting, however, the cloud direction and the wind direction may not coincide. The direction of cloud motion may shift with the wind, it may be ahead of it (that is, come from a more westerly quarter), or it may be behind it. There are thus three possibilities. If diagrams (Annals of the Harvard College Observatory, Vol. XXX) showing the distribution of the meteorological elements about a low at various levels above the earth's surface are examined, it will be seen that normally the cloud motion should be ahead of (more westerly than) the wind direction. Theory also shows that this is the expected result. Statistics will show that this is true in about six cases out of ten. In perhaps two cases the direction will be coincident and in perhaps two cases it will lag behind. The reason is twofold. In the first place, the masses of cooler air accompanying the advancing high and coming from the northwest either overrun, or underrun, or mingle with the moist, warm air accompanying the departing low and coming from a more southerly direction. If the air underruns, the surface wind will shift before the clouds; if it overruns, the clouds will shift ahead of the wind; if there is mixture, it is doubtful just which case might result. In the

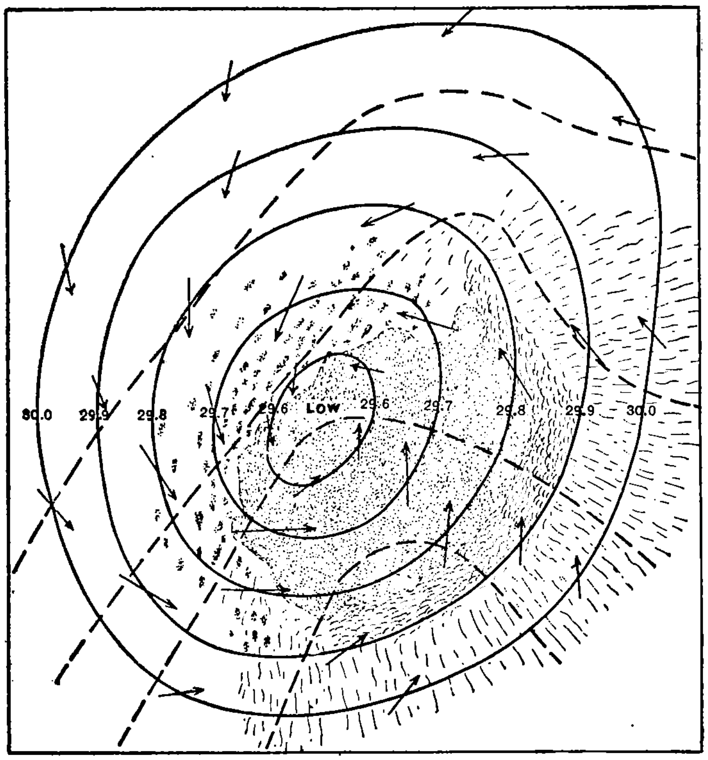

FIG. 1.—Conditions attending a gradual slow change of wind and weather.

second place the axis of a low leans backward or westward. By the axis is meant a line joining the successive centers of lowest pressure at various heights above the earth's surface. At first thought one would expect this to be perpendicular to the earth's surface, but the unequal temperature distribution on the two sides of a low causes the axis to lean backward or westward. It is well known that on a high mountain the center of a low sometimes passes an hour or so later than at the earth's surface. This leaning back of the axis will also influence the relation between the wind direction and the direction of cloud motion. The amount of the leaning is not the same for all lows, but depends on the temperature distribution about the low in question.

III. ONE CLOUD LAYER OR MORE THAN ONE.

When the lower cloud layer finally breaks through and discloses the blue sky, an upper cloud layer may be seen or there may be none. Sometimes more than one layer is glimpsed. It consists usually of cirriform or alto clouds which move from a more southerly direction than the lower clouds and usually disappear in a few hours. According to the Blue Hill observations, in 110 cases upper layers were seen 74 times. The ordinary observer who does not make many observations at night and who is not constantly on the lookout for the merest trace of an upper layer will not see as many. He will be of the opinion that not more than one low in three or four has an upper layer. The upper layer is perhaps more common after a rapid wind-shift low than after one in which the wind veers gradually.

IV. THE RAPIDITY OF CLEARING OFF.

After the rain ceases, the blue sky may appear quickly, after the normal time, slowly, or it may remain totally

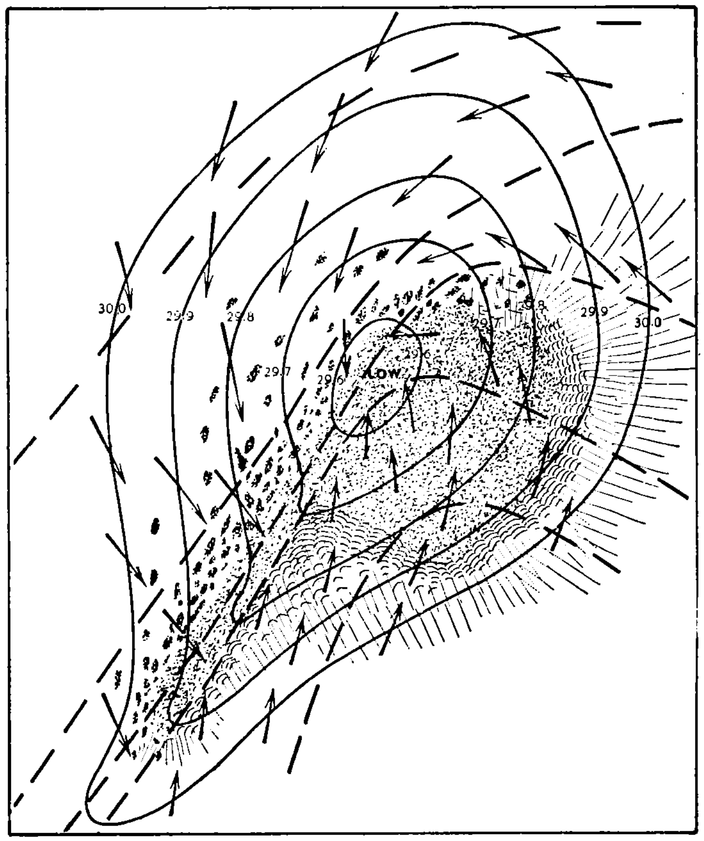

FIG. 2.—Conditions attending a sudden change of wind and weather.

cloudy until it rains again. The normal time interval between the ending of the rain and the first blue sky is perhaps four or five hours. Sometimes it may appear in an hour or two, in which case it has cleared very quickly. The clouds may last 12 hours or a whole day, in which case it has cleared very slowly. There are a few cases where it will remain totally cloudy until it rains again. The second rain must occur, however, at least 24 hours after the stopping of the first to be considered an independent, separate storm.

V. FURTHER CLASSIFICATIONS.

If simple instruments, such as a thermometer and barometer, are available, a few additional but perhaps less interesting classifications may be made. The lowest pressure usually occurs when the wind is from the southwest. Lows may be classified as wind in the southwest, wind more easterly, or more westerly when the pressure is lowest. The temperature drop after the rain ceases and the blue sky comes may also be noted. This can be classified as small, normal, or large. The rapidity or rise of the barometer may also be classified as rapid, normal, or slow.

VI. LIMITATIONS.

This classification of the sequence of events in passing from rain to blue sky applies geographically to New England or the Middle Atlantic States. This normal distribution of the meteorological elements about a low is, however, but slightly different for any part of this country and not very different for the Atlantic Ocean or for Europe.

Furthermore, it has always been a low which so moves that an observer passes through its southern quadrants, that has been considered. Now for the northwestern part of the United States this is nearly always the case. A wind that backs instead of veers is very unusual except possibly near the seacoast and in the extreme northern part. The sequence of events would be entirely different, and this has not been considered.

Furthermore, it is the winter type of storm with steadily falling rain or snow which has been considered rather than the summer type with the sultry weather and thundershowers. The best way to characterize the difference between the summer and winter type is to liken it to a machine. In the winter type the machine runs smoothly. In the summer type the machine clogs and stops and then by a thundershower is jerked forward to where it ought to be. The sequence of events goes forward by jerks rather than smoothly.

Furthermore, exact figures have not been given. It would require ten years of careful observation to do this, and but little would be gained. The value is in the classification. For example, it makes little difference whether about one low in seven has a sharp wind-shift line or it is finally found that for a definite place for a definite period of ten years it is exactly 17 per cent. This classification is based upon two or three years of casual observation and one year of critical observation to test the classification at Williamstown, Mass.

VII. SUMMARY.

As was stated at the beginning, the purpose of this article is to attempt a classification of the various methods of transition from rain to blue sky. For example, it may be said of a certain passing low which caused the rain, that the wind veered steadily instead of changing suddenly; that the direction of the cloud motion was ahead of the wind direction; that an upper cloud layer was seen for a short time; that the time required for showing blue sky was normal. It might also have been stated that the lowest pressure came with the wind from the southwest, that the temperature drop was normal, and that the pressure increase was rapid. It will thus be seen that this classification would give to anyone familiar with the various methods of transition, a definite picture of the characteristics of the passing storm. It will also add much pleasure to watching this oft occurring transition to know the various ways in which it may take place and the one in progress in the instance under observation.

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SQUALLS AND THE PREDICTION OF TORNADOES.

By E. DURAND-GRÉVILLE.

[Dated Paris, Mar. 30, 1913. Translated for the Monthly Weather Review.]

INTRODUCTORY NOTE.

The International Conference of Directors of Meteorological Observatories, which met at Innsbruck, Austria, in September, 1905, listened to an enthusiastic paper on the phenomena of squalls by M. E. Durand-Gréville. After his address Prof. H. Hildebrandsson suggested that the conference appoint a commission on squalls, its functions to be analogous to those of the International Commission on Clouds appointed by the International Meteorological Committee. Favorable action by the Conference resulted in the appointment of such a Commission composed of MM. Hildebrandsson (Upsala), Shaw (London), and Durand-Gréville (Paris).

M. Durand-Gréville was long an active student of squall phenomena, and this REVIEW has already published an exposition of his discoveries in this branch of meteorology. The publication of the present paper has been delayed by administrative changes that were impending at the time of its receipt. The Editor regrets to announce the death of its author on January 20, 1914.

SQUALLS.

What has come to be known as the "law of squalls" did not present itself to my mind at one time. Several years previous to 1890, being intrusted with the meteorological articles in the Grande Encyclopédie, I had first made myself acquainted with the earlier works, or at least with the greater number of them, notably with those of Ciro Ferrari, who, according to the expression of Hildebrandsson, was "the one who had done the most" for the knowledge of thunderstorms; also, of course, the works of Marié-Davy, written under the direction of Le Verrier.

The latter had given the simplest possible definition of a thunderstorm, viz, "any disruptive electrical discharge in the atmosphere." The definition had become complicated little by little, in proportion as the details had been studied and various brusque changes at the time of the thunderstorm had been observed, such as rise of the barometer; increase in force and change of direction of the wind; fall of temperature; increase of relative humidity, etc. I shall tell you why it seems necessary to revert to the original definition of the thunderstorm and to restore to the squall its personality, the squall serving only—as occasional cause—to rouse up the thunderstorm *at the moment* when it arrives from a distance on large cumuli previously formed.

In studying attentively the thunderstorm isochrones of Marié-Davy and more especially those of Ferrari, I perceived that there appeared to be a real correspondence between two "thunderstorm spots" not too far distant from one another and that, in certain cases, the isochrones of the two "spots" could easily be connected. If one sought to verify what took place between the two "spots," one would discover the existence of a wind squall, of a barometric "hook" (crochet), etc. This work of verification was done slowly and fragmentarily, but in the end I was persuaded—without, however, having any very tangible proof of it—that the isochronous line of a violent squall passing over a place in the morning without evoking a thunderstorm, would continue its